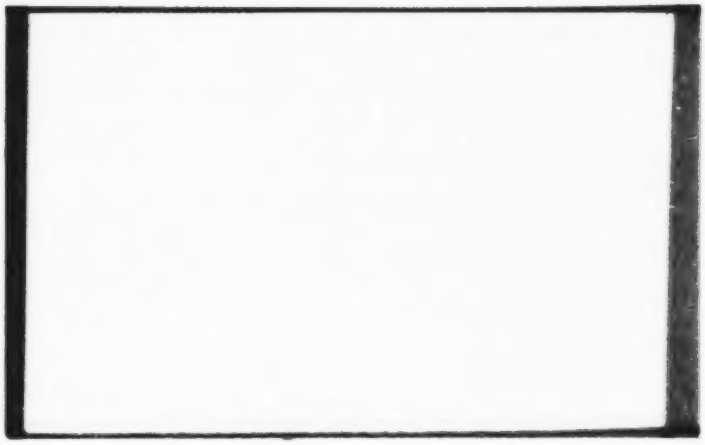
ENERGY USE ENGINEERING DEPARTMENT

PROJECT 8313

EVALUATION OF ENERGY SAVINGS RESULTING FROM THE CEA ENERGY EFFICIENT BUILDING DESIGN GUIDELINES

ENERGY CONSERVATION DIVISION

B.C. HYDRO AND POWER AUTHORITY



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PROJECT 8313

EVALUATION OF ENERGY SAVINGS RESULTING FROM THE CEA ENERGY EFFICIENT BUILDING DESIGN GUIDELINES

SYNPOSIS:

The energy use of a theoretical office building located in Toronto, Vancouver and Winnipeg was simulated using the BLAST energy analysis program. The simulations were performed for the building designed according to typical current local practice and then according to the CEA Double E guidelines.

Annual energy savings ranging from 21% to 33% were achieved by applying the Double E building guidelines, with the Vancouver building having the largest savings.

PROJECT: Initiated/Requested by: CEA Double E C&I Building Technical Committee

Date Completed: September 1983

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EVALUATION OF ENERGY SAVINGS RESULTING FROM THE CEA

ENERGY EFFICIENT BUILDING DESIGN GUIDELINES

PREPARED BY
ENERGY USE ENGINEERING DEPT.
ENERGY CONSERVATION DIVISION
B. C. HYDRO
VANCOUVER, B. C., CANADA

(This is a co-operative project carried
out under contract by B. C. Hydro for the
Canadian Electrical Association Double E Program)

Principal Investigator:
TOBY K. W. LAU

September 1983

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SUMMARY

Three similar typical 13 storey office buildings located in Toronto, Winnipeg and Vancouver, each conforming to current local new building construction practices, were simulated using the BLAST energy simulation computer program and their annual operation energy requirements predicted.

The CEA Double E Commercial and Industrial Buildings Design Award Program Guidelines were then applied to these buildings and their new annual operation requirements were again predicted through computer simulation.

Results indicated that savings in annual energy consumption of 21% to 33% could be realized by adopting the Double E program guidelines for new building constructions. Annual energy cost savings ranged from $3.39 to $1.64 per m² per year ($0.31 to $0.15 per sq ft per year).

An additional benefit apparent from the results is the reduced size of the mechanical equipment required by the energy efficient building. This will at least partially offset the added costs for the energy efficient building shell and heat recovery equipment.

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APPENDIX

1 INTRODUCTION

The CEA Double E Commercial and Industrial Building Design Award Program was designed to include the best methods of achieving energy efficiency in buildings, considering practicability, limitations of currently available equipment and economic viability. This study was undertaken to estimate the annual energy consumption of a fictitious typical office building that was designed according to the CEA Double E Commercial and Industrial Building Guidelines and compare it to a base building that was designed according to current local construction practices. The reduction in energy consumption that could be achieved by conforming to the Double E program could then be analyzed.

The Building Load Analysis and System Thermodynamics (BLAST) building energy computer program was used to simulate the energy flow pattern of the office buildings and to derive the annual energy consumption.

As requested by the CEA Double E Commercial and Industrial Building Technical Committee, three locations across Canada were studied - they were Toronto, Winnipeg and Vancouver.

2 CHARACTERISTICS OF THE TYPICAL BASE BUILDING

Commercial and industrial buildings vary greatly in shape, size, orientation, glazing, etc. In this study, a typical office building was used, since the absolute energy consumption value of a building bore no significance in the analysis - the key element being the energy consumption per unit floor area.

Through computer simulation using different weather tapes, the same building was "carried" across Canada and simulated for the three cities - Toronto, Winnipeg and Vancouver. The characteristics of the building remained basically the same for all three locations, except that the insulation levels, inside lighting intensity, and building operation was altered to conform with current local new construction practice.

2.1 ARCHITECTURE

The architecture is shown in Figures 1, 2, 3, 4 and 5.

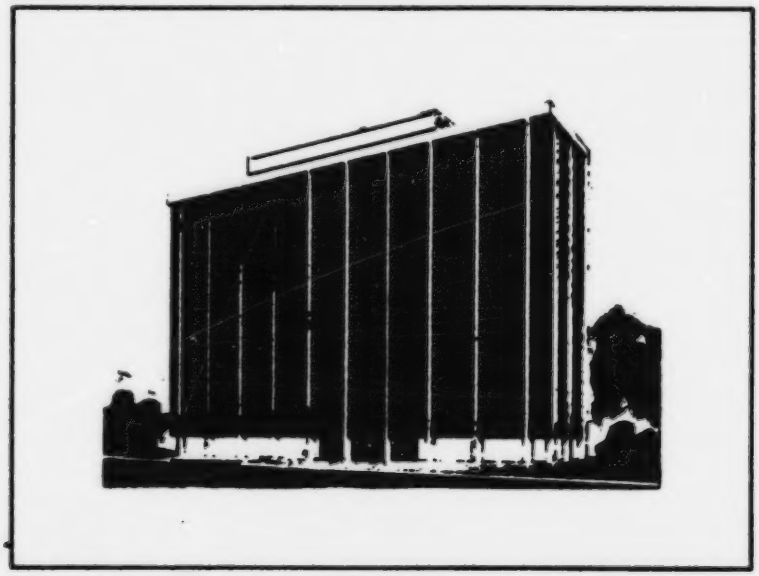

FIGURE 1

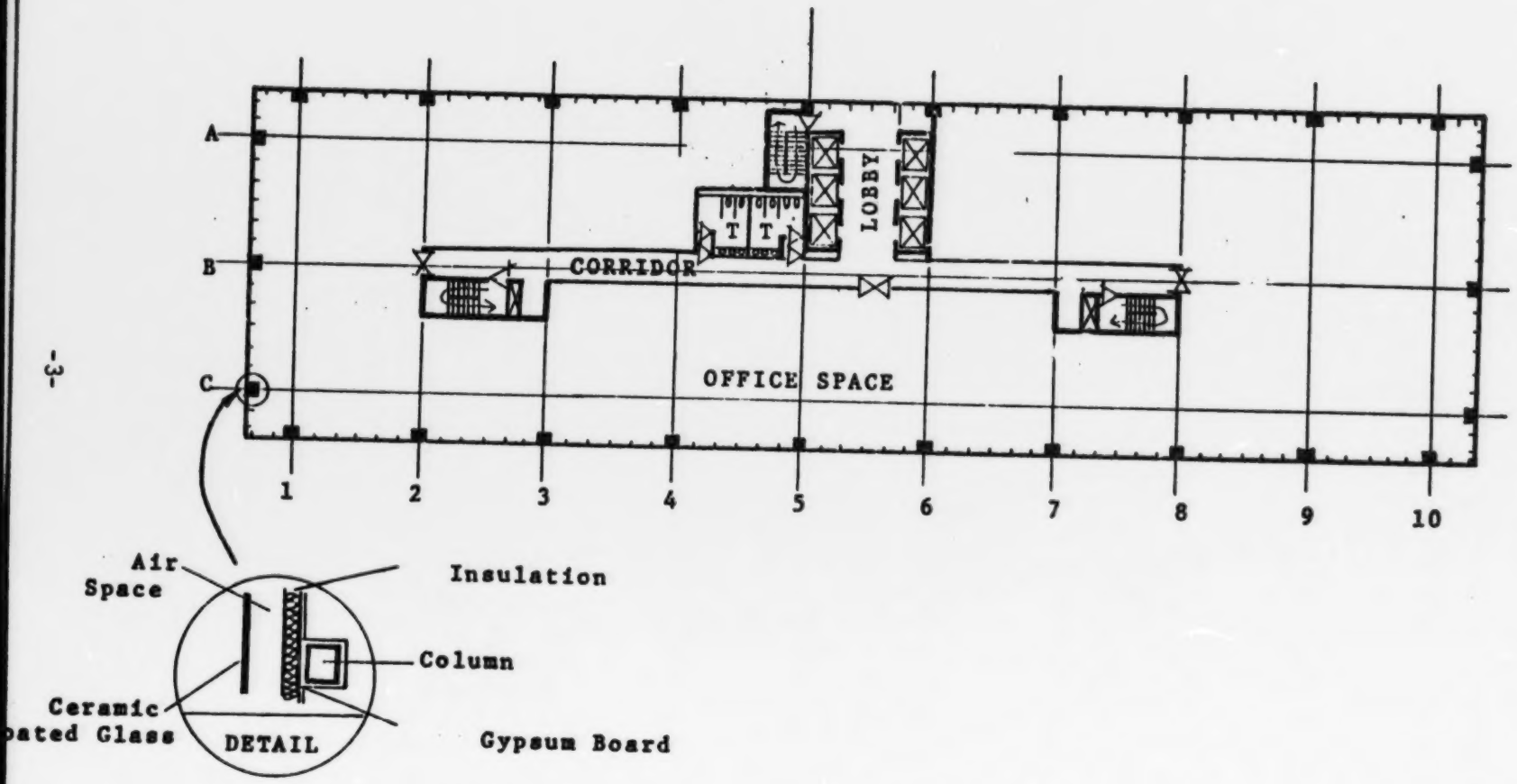

FIG. 2 TYPICAL FLOOR PLAN & WALL SECTION

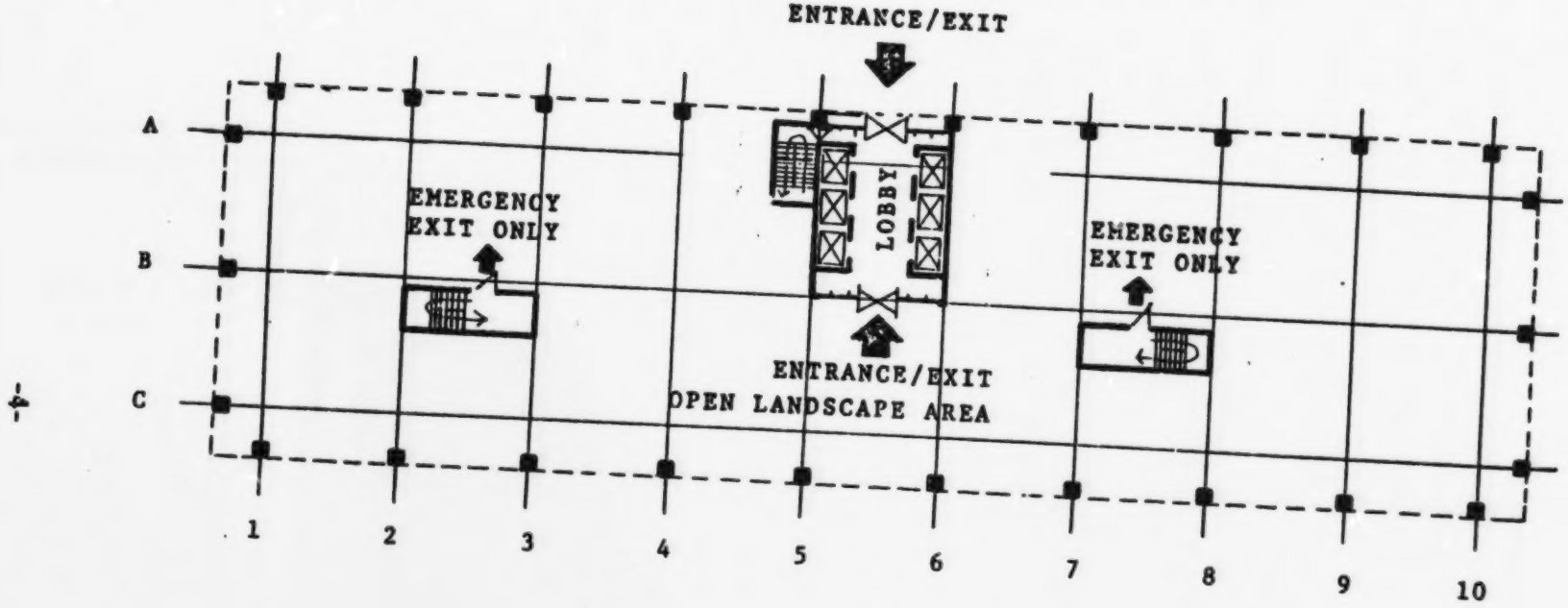

FIG. 3 GROUND FLOOR PLAN

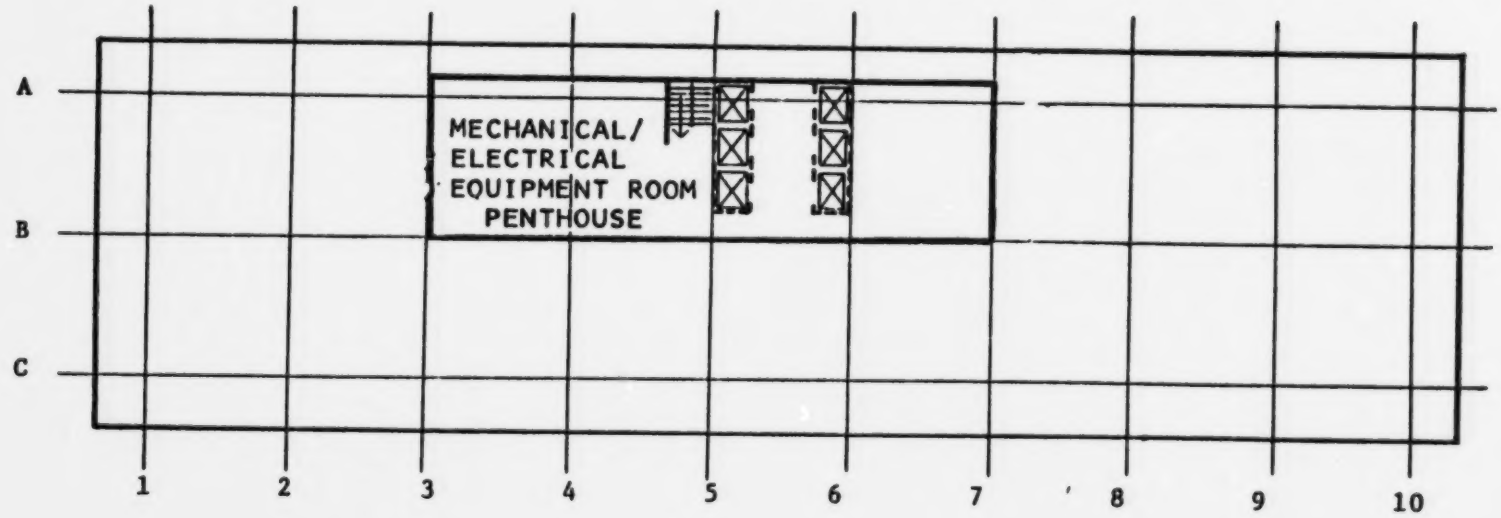

FIG. 4 ROOF PLAN

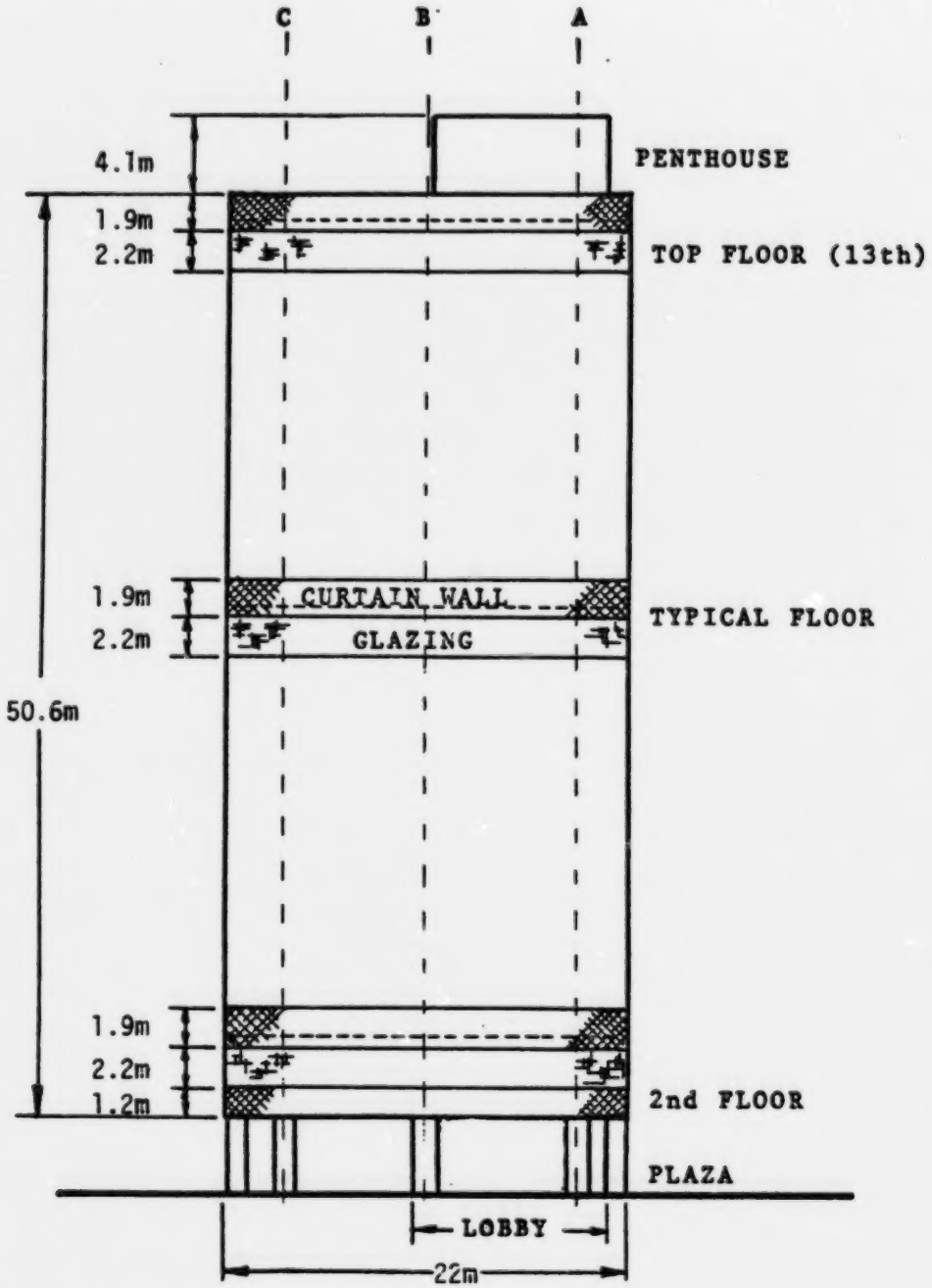

FIG. 5 WEST ELEVATION

2.1.1 Shape

Rectangular with north facade facing 30° west of true north.

2.1.2 Height

13 stories resting on raised columns; 12 occupied typical floors, penthouse, and ground floor plaza.

2.1.3 Gross Areas

Building total of 21 440 m² (230 700 sq ft) and 12 typical floors at 1 750 m² (18 800 sq ft) each.

2.1.4 Structure

Steel frame with 100 mm (4 in) concrete floor slabs. Lobby elevator shaft and escape staircase 200 mm (8 in) cast-in-situ concrete.

2.1.5 Penthouse

34 m (112 ft) long and 9.8 m (32 ft) wide centered on roof. Contains all mechanical, electrical equipment and elevator machinery.

2.1.6 Entry Lobby

Situated at grade level, containing the six elevator hoistways, lobby and staircase.

2.1.7 Grade Level Plaza

Slab-on-grade with open landscaped area, 5.5 m (18 ft) floor to floor with 4.3 m (14 ft) suspended ceiling, including the entry lobby.

2.1.8 Typical Floor

80 m (261 ft) long and 22 m (72 ft) wide, 4.1 m (13.5 ft) floor to floor and 2.6 m (8.5 ft) ceiling heights.

2.1.9 Walls

Dark coloured glass face curtain wall with insulation on all walls.

2.1.10 Interior Partitions

Gypsum board on each side of slab to slab metal studs.

2.1.11 Floors

Carpets on 100 mm (4 in) concrete slab.

2.1.12 Ceilings

Suspended acoustical tile with lay-in fluorescent light fixtures on typical floors. Suspended metal lath and plaster ceiling below second floor slab.

2.1.13 Roof

Insulated built-up roof on 100 mm (4 in) concrete slab.

2.1.14 Window Glass

53% of typical floor facade, 6 mm (¼ in) Solargrey (heat absorbing) single glazed for Vancouver and double glazed for Toronto and Winnipeg. Mounted flush to outside wall face, no interior blinds.

2.1.15 Lobby

12 mm (½ in) Solargrey single glazed for Vancouver and double glazed for Toronto and Winnipeg, at north and south ends of entry lobby.

2.1.16 Wall Insulation

RSI 2.1 (R12) for Vancouver, Toronto and Winnipeg.

2.1.17 Roof Insulation

RSI 3.5 (R20) for Vancouver, RSI 1.8 (R10) for Toronto and RSI 4.2 (R24) for Winnipeg.

2.1.18 Exposed Floor Insulation

RSI 3.5 (R20) for Vancouver, RSI 2.1 (R12) for Toronto and RSI 4.2 (R24) for Winnipeg.

The insulation levels used for the three different cities were gathered through local concensus as being the levels of insulation used in new constructions. The figures for Vancouver were based on a general knowledge of current practice, together with discussions with building designers. Figures for Toronto were obtained from Ontario Hydro and for Winnipeg from Manitoba Hydro.

2.2 AIR LEAKAGE - INFILTRATION

Infiltration of outside air assumed in the base building was 1.5 L/s per m^2 (0.3 CFM per sq ft) for the exterior zones.

2.3 HEATING, VENTILATING AND AIR CONDITIONING CRITERIA

2.3.1 Locations

(a) Toronto, Ontario
(b) Winnipeg, Manitoba
(c) Vancouver, British Columbia

2.3.2 Design Days

(a) Winter - 21st January
(b) Summer - 21st August

2.3.3 Design Days Outside Conditions

(a) Winter - January @ 2½%
(b) Summer - 1% Design Dry Bulb and Wet Bulb

2.3.4 Weather Tape Year

Year 1981 was used for all three locations.

2.3.5 Surroundings

Located in suburban terrain with no tall building in the area. The building is immediately surrounded by a bituminous surfaced parking lot and further away by low rise commercial buildings.

2.3.6 Lighting

Recessed fluorescent fixtures with prismatic lens throughout the building, 32 W/m² (3.0 W/sq ft) in the offices for the Vancouver building, 27 W/m² (2.5 W/sq ft) for the Toronto and 22 W/m² (2 W/sq ft) for the Winnipeg building. 10.8 W/m² (1 W/sq ft) in the lobby, toilets and corridors. Emergency lighting constitutes 5% of the total connected lighting load.

2.3.7 Office Equipment

Equipment normally associated with general office type activities is assumed throughout the building at 5 W/m² (0.5 W per sq ft) and had the same operation profile as the office lighting.

2.3.8 Occupancy

Occupancy density of 9 m² per person (100 sq ft per person) in the office areas.

2.3.9 Ventilation

2.4 L/s (5 CFM) per person in all office areas and 0.1 L/s per m² (2 CFM/100 sq ft) in all circulation spaces.

2.3.10 Inside Temperature

(a) 21°C (70°F) Daytime for the Vancouver and Winnipeg buildings, 24°C (75°F) for the Toronto Building

(b) 10°C (50°F) Nighttime for the Vancouver and Winnipeg buildings, 15.5°C (60°F) for the Toronto Building

2.3.11 Humidification

Humidification is not provided.

2.4 HEATING, VENTILATING AND AIR CONDITIONING SYSTEM DESCRIPTION

The building was separated into 20 thermal zones. They are as follows:

(a) Zone #1 - typical floor south
(b) Zone #2 - typical floor west
(c) Zone #3 - typical floor east
(d) Zone #4 - typical floor north
(e) Zone #5 - typical interior
(f) Zone #6 - typical lobby/corridor
(g) Zone #7 - entrance lobby

(h) Zone #8 - 2nd floor south
(i) Zone #9 - 2nd floor west
(j) Zone #10 - 2nd floor east
(k) Zone #11 - 2nd floor north
(l) Zone #12 - 2nd floor interior
(m) Zone #13 - 2nd floor lobby/corridor
(n) Zone #14 - top floor south
(o) Zone #15 - top floor west
(p) Zone #16 - top floor east
(q) Zone #17 - top floor north
(r) Zone #18 - top floor interior
(s) Zone #19 - top floor lobby/corridor
(t) Zone #20 - penthouse mechanical room

2.4.1 Supply Air Fan Systems

Three variable air volume (VAV) fan systems were used to serve the zones. Each VAV system with insulated sheet metal ducts extended to each zone for above ceiling distribution to ceiling outlets. VAV box minimum stops were sized based on the winter design condition and the systems were operating at a fixed cold deck temperature. Reheat coils were installed in perimeter zones. (Figure 6 shows the general layout of the VAV fan systems.)

All systems take return air from common ceiling plenums on each floor using the duct shaft to the penthouse. All fan systems have fixed amount of outside air. All VAV fans have inlet guide vane for pressure control. Air is supplied to all areas except toilets, staircase and mechanical room.

Supply and return air rates are balanced except for the fan system serving the toilet area where the return air volume equals the supply air volume less the exhaust air rate.

Service of the fan systems are as follows:

(a) Perimeter zones #1, 3, 8, 10, 14 and 16 are served by a VAV fan system with reheat coils.

(b) Perimeter zones #2, 4, 7, 9, 11, 12, 13, 15, 17, 18 and 19 are served by a second VAV fan system with reheat coils.

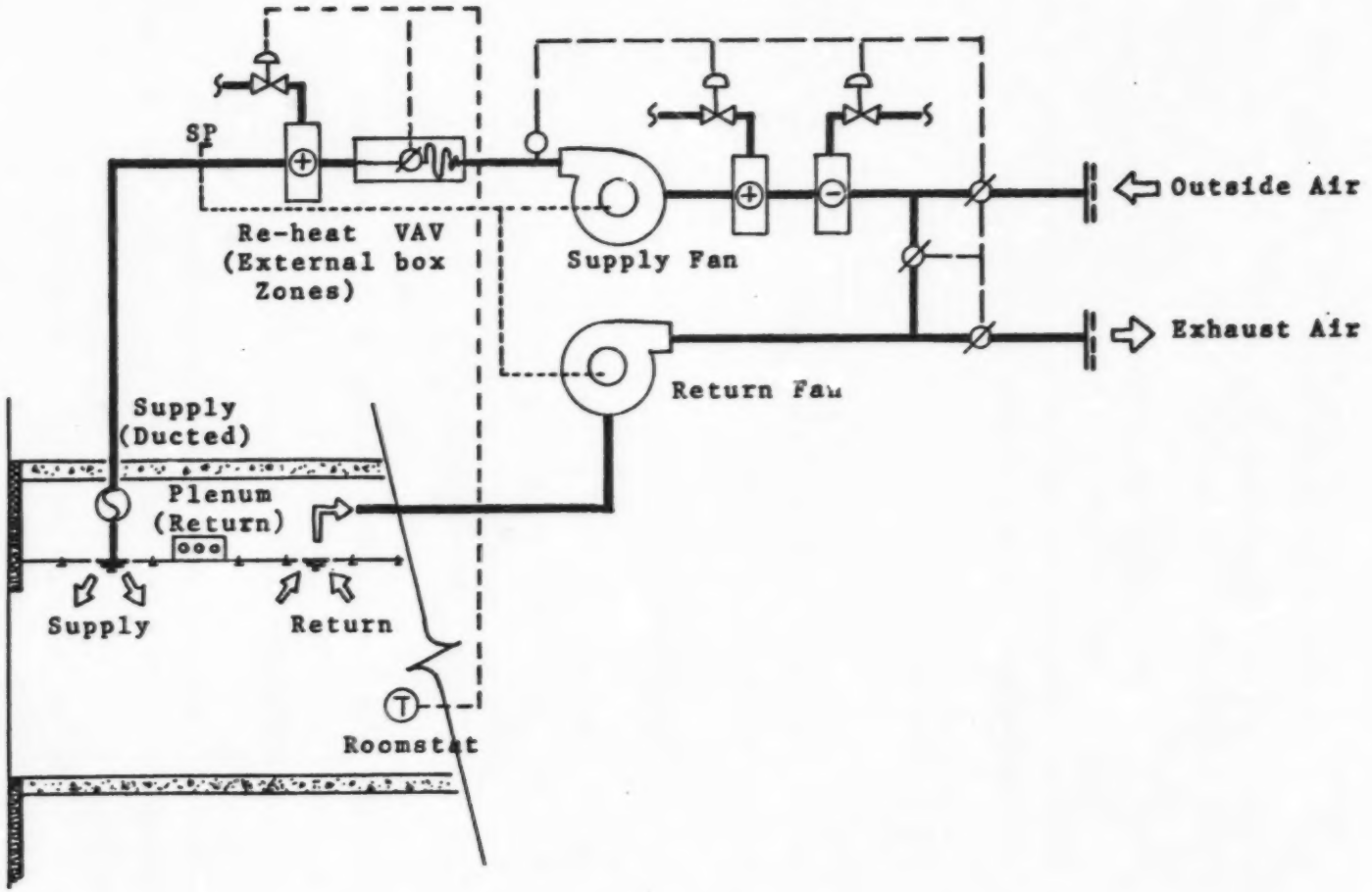

FIG. 6 HVAC ARRANGEMENT

(c) Interior zones #5 and 6 are served by a third VAV fan system without reheat coils.

2.4.2 Supply Air

Constant primary supply air at 13°C (55°F). Draw through supply fan selected at 80% efficiency and 1 125 Pa (4.5 in) total pressure [1 000 Pa (4 in) static and 125 Pa (0.5 in) velocity pressure]. 90% efficient motors located outside of air stream.

2.4.3 Return Air

Fan selected at 80% efficiency and 500 Pa (2 in) total pressure [375 Pa static and 125 Pa (0.5 in) velocity pressure]. 90% efficient motors located outside of air stream.

2.4.4 Toilet Exhaust

283 L/s (600 CFM) per floor at 375 Pa (1.5 in) static pressure with constant 65% overall efficiency. Fan operates only when supply fan is on.

2.5 CENTRAL PLANT EQUIPMENT

All central plant equipment is located in the penthouse.

2.5.1 Chillers

Two electric driven centrifugal chillers connected in parallel, loaded sequentially and each sized for 60% of the peak cooling load with 7.2°C (45°F) chilled water temperature.

2.5.2 Chiller Water Pump

One, sized at 180 kPa (60 ft) of head and 75% overall efficiency. Chilled water supply and return temperature difference = 5.5°C (10°F).

2.5.3 Condenser Water Pump

One, sized at 180 kPa (60 ft) of head and 75% overall efficiency. Condenser water inlet and outlet temperature difference = 5.6°C (10°F).

2.5.4 Cooling Tower

Cooling tower with induced draft fans. Cooling tower is sized and controlled to maintain constant condenser cooling temperature.

2.5.5 Boilers

Two natural gas-fired hot water boilers connected in series loaded sequentially, and each sized for 60% of the peak heating design load.

2.5.6 Heating Hot Water Pump

One, sized at 240 kPa (80 ft) of head and 75% overall efficiency. Heating hot water supply and return water temperature difference = 16.7°C (30°F).

2.6 HEATING, VENTILATING AND AIR CONDITIONING SYSTEM CONTROLS

2.6.1 Fan System Operation

System to operate five days per week with no holidays. System is to be turned on at 7:00 a.m. and shut off at 5:00 p.m. Nighttime and weekend setback minimum is 10°C (50°F) in winter and no maximum required in summer. Supply, return and exhaust fans are electrically inter-locked. During the setback periods, should the space temperature drop below 10°C (50°F), the system would operate to maintain the space temperature at 10°C (50°F) for the Vancouver and Winnipeg buildings, or 15.6°C (60°F) for the Toronto building.

2.6.2 Heating System Operation

The heating system operates continuously throughout the whole year.

2.6.3 Cooling System Operation

For the Vancouver and Winnipeg buildings, the cooling system operates only between, and including, the months of April and September and in those months only between the hours as scheduled in Section 2.6.1. For the Toronto buildings, the cooling is provided all year round and between the hours as scheduled in Section 2.6.1.

2.7 BASE ELECTRIC LOAD

Elevator load is at 175 kW (full load).

2.8 BUILDING SERVICE WATER

Building service hot water is provided by the two central gas-fired hot water boilers, and with a probable demand of 9 kW (30 MBH).

2.9 BUILDING USE AND OCCUPANCY

Normal office hours are 9:00 a.m. to 5:00 p.m. with one hour for lunch between noon and one. The occupants have advised that overtime is not normally worked and at any one time, some 95% of the total staff can be expected to be working (excluding lunch hours). No lunch facilities are provided in the building.

Cleaning of the building is carried out every evening between the hours of 5:00 p.m. and 9:00 p.m. by six gangs of four cleaners, each gang cleans one floor every two hours.

2.10 BUILDING LIGHTING USE

All circulation lighting is turned on at 7:00 a.m. Office lighting will be turned on by the office staff as they arrive. In the evening, the cleaning staff are responsible for turning off the office lighting as they finish cleaning a floor. All circulation lighting, except emergency/security lighting, is turned off at 10:00 p.m. Emergency lighting operates continuously.

3 THE CEA DOUBLE E MODEL BUILDING

The Double E model building was assumed to have the same physical shape and size of the base model building. Building use, occupancy, lighting and mechanical system operation schedules are also retained for the Double E model.

The CEA Double E Commercial and Industrial Guidelines extracted and applied to the Double E building model were as below.

3.1 BUILDING ENCLOSURES

3.1.1 Building Assembly Thermal Resistance

Location	Toronto	Winnipeg	Vancouver
Celsius Degree Days	4 082	5 887	3 005
Exterior Wall	*RSI 3.3 (R19)	RSI 4.0 (R23)	RSI 2.5 (R14)
Roof	RSI 6.5 (R37)	RSI 7.5 (R43)	RSI 5.0 (R28)
Exposed Floor	RSI 6.5 (R37)	RSI 7.0 (R40)	RSI 5.0 (R28)

* Note: RSI - thermal resistance in $m^2.°C/W$
R - thermal resistance in sq ft °F/Btuh

3.1.2 Glazing

Complying with Article 3.2.4 of the Double E Building Guidelines, the glazing of the office tower was reduced from 2.2 m (7.3 ft) to 1.2 m (4 ft) high. The glazing in the entrance lobby was to remain the same. The glazing type for the three locations are as follows:

Location:	Toronto	Winnipeg	Vancouver
Type of Glazing:	Double	Triple	Double

In all three locations, the outer panes were assumed to be Solargrey.

3.1.3 Infiltration

Due to the many variables affecting a building infiltration rate, it is not possible to accurately calculate the reduction in infiltration due to the air tightness requirements in the Double E Guidelines. In order to be conservative, it was assumed that the infiltration for the Double E building would be 10% less than that of the base model building.

3.2 HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS

The heating, cooling and ventilating system of the Double E model building has the same system layout as the base model building, with the exception of the following features.

3.2.1 Temperature Control

Thermostats controlling the space cooling and space heating equipment operations were set to have a 2.8°C (5°F) heating and cooling dead-band. That is, during the daytime operation, the cooling system would be activated when the space temperature exceeded 24°C (75°F) and the heating system would operate when space temperature dropped below 21°C (70°F).

During the unoccupied periods, the same setback temperature schedule of the base building would be in effect, with no maximum temperature for cooling requirement.

3.2.2 Simultaneous Heating and Cooling

The VAV systems in the Double E model building were equipped with controls that automatically reset the primary cold deck supply air temperature to the highest temperature that will satisfy the zone which required the coolest air.

3.2.3 Cooling With Outdoor Air

Return air and outdoor air enthalpy economizer controls were used with the VAV fan system to provide free cooling whenever the outdoor air enthalpy was lower than the return air enthalpy.

3.2.4 Heat Recovery Systems

Heat recovery systems were assumed in the Double E model building to recover heat from the building exhaust and relief air. The equipment was to have sensible heat recovery efficiency of 60%.

3.3 ELECTRIC LIGHTING

The total building lighting connected load was reduced to 22 W/m^2 (2 W/sq ft) in the office areas.

4 THE BLAST PROGRAM

The Building Load Analysis and System Thermodynamics (BLAST) program was developed by the U. S. Army Construction Engineering Research Laboratory (CERL). This program is a comprehensive set of sub-programs for predicting energy consumption and energy system performance and cost in buildings. There are three major sub-programs:

(a) The Space Load Predicting Sub-Program computes hourly space loads in a building or zone based on user input and weather data.

(b) The Air Distribution System Simulation Sub-Program uses the computed space loads, weather data and user inputs describing the building air handling system to calculate hot water, steam, gas, chilled water and electric demands.

(c) The Central Plant Simulation Sub-Program uses weather data, results of air distribution system simulation and user input describing the central plant to simulate boilers, chillers, on-site power generating equipment and solar energy systems, and computes monthly and annual fuel and electrical power consumption.

The BLAST program differs in three key respects from similar programs used in the past:

(a) The BLAST program uses extremely rigorous and detailed algorithms to compute loads, simulate fan systems and simulate boiler and chiller plants.

(b) The program has its own user-oriented input language and is accompanied by a library which contains the properties of all materials, wall, roof and floor sections listed in the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals 1977.

(c) The program is public domain, and is therefore, open to inspection by its users and those who rely on its results.

The BLAST program Version 3.0, which resides in the Boeing Computer Services Data Centre, was used in the analysis of this report.

5 RESULTS

Results obtained from the computer simulation for the three locations are listed as below.

5.1 LOCATION: TORONTO

	Base Bldg	Double E Bldg
Design Cooling Peak Thermal Load (kW)	1 830	1 460
Design Heating Peak Thermal Load (kW)	1 980	1 610
Annual Electrical Peak Demand (kW)	1 240	1 020
Annual Electrical Consumption (GWh)	3.83	2.37
Annual Heating Consumption (TJ)	16.67	12.93
Total Annual Consumption Per Unit Floor Area[1] (kWh/m²)	396	279
Total First Year Energy Cost[2] ($)	238 200	165 800

Table 1

Note: [1] Based on total floor area of 21 380 m² (230 000 sq ft).
[2] Based on current energy costs in Toronto.

5.2 LOCATION: WINNIPEG

	Base Bldg	Double E Bldg
Design Cooling Peak Thermal Load (kW)	1 960	1 370
Design Heating Peak Thermal Load (kW)	2 750	2 120
Annual Electrical Peak Demand (kW)	1 200	980
Annual Electrical Consumption (GWh)	3.32	2.39
Annual Heating Consumption (TJ)	15.16	12.83
Total Annual Consumption Per Unit Floor Area[1] (kWh/m²)	352	279
Total First Year Energy Cost[2] ($)	182 400	147 400

Table 2

Note: [1] Based on total floor area of 21 380 m² (230 000 sq ft).
[2] Based on current energy costs in Winnipeg.

5.3 LOCATION: VANCOUVER

	Base Bldg	Double E Bldg
Design Cooling Peak Thermal Load (kW)	2 170	1 290
Design Heating Peak Thermal Load (kW)	2 135	1 400
Annual Electrical Peak Demand (kW)	1 370	900
Annual Electrical Consumption (GWh)	4.0	2.34
Annual Heating Consumption (TJ)	7.1	6.0
Total Annual Consumption Per Unit Floor Area[1] (kWh/m²)	281	187
Total First Year Energy Cost[2] ($)	164 800	108 800

Table 3

Note: [1] Based on total floor area of 21 380 m² (230 000 sq ft).
[2] Based on current energy costs in Vancouver.

6 DISCUSSION

From the results indicated in Tables 1 to 3 in Section 5, the Vancouver Double E building yielded the largest savings in annual energy consumption from its base model building, of approximately 33%. Table 4 below summarizes the various percentage savings that were achieved by the Double E building for the three cities.

Location:	% Reduction		
	Toronto	Winnipeg	Vancouver
Design Cooling Peak Thermal Load	20	30	41
Design Heating Peak Thermal Load	19	23	34
Annual Electrical Peak Demand	18	18	34
Annual Electrical Consumption	38	28	34
Annual Heating Consumption	22	15	15
Total Annual Energy Consumption	30	21	33
First Year Energy Cost	30	19	34

Table 4

In addition to the results indicated in Table 4, the Toronto and Winnipeg buildings were simulated with different cooling operation schedules than those stated in Section 2, hence a range of saving was obtained for those two locations. The variation in cooling operation schedules were:

(a) Winnipeg Buildings

The cooling system was altered to operate all year round and between the hours as stated in Section 2.6.1.

(b) Toronto Buildings

The cooling system was cut back to operate between and including the month of April and September, and between the hours as stated in Section 2.6.1. At the same time, the summer inside temperature was reduced to 21°C (70°F) and setback temperature was changed to 10°C (50°F).

The Vancouver building cooling schedule was not altered, since it was felt that the schedule indicated in Section 2 would be representative.

The percentage reduction for the Toronto and Winnipeg buildings with their new cooling operation schedules are as below.

Location:	% Reduction Toronto	Winnipeg
Design Cooling Peak Thermal Load	29	30
Design Heating Peak Thermal Load	15	23
Annual Electrical Peak Demand	24	18
Annual Electrical Consumption	38	34
Annual Heating Consumption	1	26
Total Annual Energy Consumption	20	30
First Year Energy Cost	25	26

Table 5

The weather year used in the simulations was 1981. Year 1981 might not be a typical weather year for the locations studied, however, it was considered to be sufficient to estimate the savings that could be achieved by new building designs complying with the CEA Double E Design Award Program.

Heat recovery (double-bundle) chillers were not included in the Double E building models, as it was felt that high initial costs of the heat pump chillers and its associated mechanical system (e.g. larger piping, bigger coils, etc.) would make them unjustifiable for this particular study. However, this does not apply in every case, and further studies using life cycle costing and optimization techniques would be necessary to prove the value of their usage.

Due to lack of data, it was assumed infiltration of outside air was reduced by 10% in the Double E building model. This was felt to be conservative and it is likely in many cases that higher annual energy savings could be realized.

Ventilation rates of 2.4 L/S (5 CFM) per person were used for both the base building and the Double E building. This is a low value which is taken from ASHRAE Standard 62-1981. It is probably not typical of current practice and although the ASHRAE standard is referenced by the Double E Guidelines, the 2.4 L/S per person is a minimum rate and will not always be appropriate. If higher rates were used and/or if a ventilation rate for the Double E building which is lower than for the base building is used, then the calculated savings would be increased.

7 CONCLUSIONS

By incorporating the CEA Double E Commercial and Industrial Building Design Program Guidelines into current local building construction practices, annual energy consumption savings of 21% to 33% were realized for the buildings studied in this report. These figures are believed to be conservative due to the judgements made in treating infiltration and ventilation rates and heat recovery requirements.

The CEA Double E program not only can help reduce building energy consumption, but also will decrease building heating and cooling demands which in turn, means smaller chillers and boilers, less mechanical room space and lower initial mechanical capital costs. Smaller mechanical equipment also means lower electrical demand to operate and hence reduces operating costs.

In order to make full use of all the recommendations outlined in the CEA Double E Building Design Award Program, further studies which include life cycle costing and optimization of each feature suggested in the program are recommended.

A P P E N D I X

The BLAST Program Result Printouts

1. Vancouver Base Building A-1

2. Vancouver Double E Building A-2

3. Toronto Base Building A-3

4. Toronto Double E Building A-4

5. Winnipeg Base Building A-5

6. Winnipeg Double E Building A-6

CENTRAL PLANT ENERGY UTILIZATION SUMMARY

MONTH	TOTAL HEAT ENERGY (GBTU)	TOTAL ELECTR ENERGY (GBTU)	COOLING ENERGY (GBTU)	RCVRED ENERGY (GBTU)	WASTED RCVRABL ENERGY (GBTU)	HEAT EN INPUT COOLING (GBTU)	ELEC EN INPUT COOLING (GBTU)	ENERGY INPUT HEATING (GBTU)	ENERGY INPUT ELECTRC (GBTU)	TOTAL FUEL INPUT (GBTU)	TOTAL ENERGY INPUT (GBTU)	AVERAGE PLANT EFFIC (PERCT)
1	.5506	1.0831	.0003	0.0000	0.0000	0.0000	.2153	.9127	3.6104	.9127	4.5231	36.
2	.4861	1.0029	.0004	0.0000	0.0000	0.0000	.2471	.7957	3.3430	.7957	4.1388	36.
3	.2491	1.1163	.0004	0.0000	0.0000	0.0000	.3256	.4286	3.7209	.4286	4.1494	33.
4	.5338	1.2760	.8317	0.0000	0.0000	0.0000	.7884	.8232	4.2532	.8232	5.0764	36.
5	.3283	1.1883	.8225	0.0000	0.0000	0.0000	.8481	.5089	3.9611	.5089	4.4699	34.
6	.2670	1.1973	.9133	0.0000	0.0000	0.0000	.8370	.4196	3.9910	.4196	4.4106	33.
7	.1429	1.2284	1.0597	0.0000	0.0000	0.0000	.8789	.2383	4.0948	.2383	4.3331	32.
8	.1082	1.2087	1.0905	0.0000	0.0000	0.0000	.8942	.1822	4.0289	.1822	4.2111	31.
9	.2648	1.1913	.9708	0.0000	0.0000	0.0000	.8633	.4125	3.9712	.4125	4.3837	33.
10	.1826	1.0869	.0005	0.0000	0.0000	0.0000	.4147	.3078	3.6230	.3078	3.9308	32.
11	.3319	1.0404	.0005	0.0000	0.0000	0.0000	.3309	.5579	3.4679	.5579	4.0258	34.
12	.7279	1.0953	.0002	0.0000	0.0000	0.0000	.1867	1.1650	3.6511	1.1650	4.8161	38.
	4.1732	13.7149	5.6907	0.0000	0.0000	0.0000	6.8302	6.7524	45.7164	6.7524	52.4687	34.

Total Electricity Consumption

Total Heating Fuel Consumption

CENTRAL PLANT

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CENTRAL PLANT ENERGY UTILIZATION SUMMARY

PLANT NUMBER= 1, CENTRAL PLANT

PLANT LOCATION = 18447 TD1440 -- VANCOUVER,B.C. IAP 1981 SIMULATION PERIOD 1JAN1981 - 31DEC1981

MONTH	TOTAL HEAT ENERGY (GBTU)	TOTAL ELECTR ENERGY (GBTU)	COOLING ENERGY (GBTU)	RCVRED ENERGY (GBTU)	WASTED RCVRABL ENERGY (GBTU)	HEAT EN INPUT COOLING (GBTU)	ELEC EN INPUT COOLING (GBTU)	ENERGY INPUT HEATING (GBTU)	ENERGY INPUT ELECTRC (GBTU)	TOTAL FUEL INPUT (GBTU)	TOTAL ENERGY INPUT (GBTU)	AVERAGE PLANT EFFIC (PERCT)
1	.5188	.6259	.0003	0.0000	0.0000	0.0000	.1346	.8515	2.0865	.8515	2.9380	39.
2	.4485	.5754	.0004	0.0000	0.0000	0.0000	.1475	.7317	1.9181	.7317	2.6498	39.
3	.3082	.6569	.0004	0.0000	0.0000	0.0000	.1936	.5174	2.1897	.5174	2.7071	36.
4	.3058	.6729	.0167	0.0000	0.0000	0.0000	.2025	.5047	2.2429	.5047	2.7476	36.
5	.1725	.6615	.0503	0.0000	0.0000	0.0000	.2576	.2889	2.2051	.2889	2.4940	33.
6	.1513	.6944	.1005	0.0000	0.0000	0.0000	.2597	.2619	2.3147	.2619	2.5766	33.
7	.1033	.7441	.3174	0.0000	0.0000	0.0000	.3521	.1905	2.4802	.1905	2.6707	32.
8	.0836	.7561	.4617	0.0000	0.0000	0.0000	.4252	.1551	2.5203	.1551	2.6754	31.
9	.1457	.7027	.2100	0.0000	0.0000	0.0000	.3158	.2513	2.3424	.2513	2.5937	33.
10	.2293	.6579	.0005	0.0000	0.0000	0.0000	.2424	.3825	2.1930	.3825	2.5755	34.
11	.3445	.6033	.0005	0.0000	0.0000	0.0000	.1949	.5694	2.0109	.5694	2.5803	37.
12	.6046	.6316	.0002	0.0000	0.0000	0.0000	.1160	.9690	2.1054	.9690	3.0745	40.
	3.4160	7.9828	1.1588	0.0000	0.0000	0.0000	2.8420	5.6739	26.6093	5.6739	32.2832	35.

Total Electricity Consumption

Total Heating Fuel Consumption

Vancouver Double E Building

CENTRAL PLANT ENERGY UTILIZATION SUMMARY

PLANT NUMBER= 1, CENTRAL PLANT

PLANT LOCATION = 68655 TORONTO - 1981 TDF1440 - TORONTO IAP,CAN SIMULATION PERIOD 1JAN1981 - 31DEC1981

MONTH	TOTAL HEAT ENERGY (GBTU)	TOTAL ELECTR ENERGY (GBTU)	COOLING ENERGY (GBTU)	RCVRED ENERGY (GBTU)	WASTED RCVRABL ENERGY (GBTU)	HEAT EN INPUT COOLING (GBTU)	ELEC EN INPUT COOLING (GBTU)	ENERGY INPUT HEATING (GBTU)	ENERGY INPUT ELECTRC (GBTU)	TOTAL FUEL INPUT (GBTU)	TOTAL ENERGY INPUT (GBTU)	AVERAGE PLANT EFFIC (PERCT)
1	2.2638	1.0625	.5721	0.0000	0.0000	0.0000	.3667	3.2563	3.5416	3.2563	6.7979	49.
2	1.3876	.9810	.5569	0.0000	0.0000	0.0000	.3820	2.0650	3.2702	2.0650	5.3352	44.
3	1.3061	1.1164	.6479	0.0000	0.0000	0.0000	.4701	1.9648	3.7212	1.9648	5.6859	43.
4	.6549	1.1716	.7182	0.0000	0.0000	0.0000	.6814	1.0612	3.9054	1.0612	4.9666	37.
5	.4083	1.1098	.7381	0.0000	0.0000	0.0000	.7249	.6827	3.6994	.6827	4.3821	35.
6	.1677	1.0693	.9563	0.0000	0.0000	0.0000	.7483	.2964	3.5644	.2964	3.8609	32.
7	.1289	1.0806	1.0590	0.0000	0.0000	0.0000	.7687	.2277	3.6019	.2277	3.8297	32.
8	.1386	1.0420	.9511	0.0000	0.0000	0.0000	.7298	.2437	3.4732	.2437	3.7169	32.
9	.3570	1.0907	.8401	0.0000	0.0000	0.0000	.7111	.5924	3.6357	.5924	4.2281	34.
10	.7976	1.1959	.6824	0.0000	0.0000	0.0000	.6735	1.2795	3.9862	1.2795	5.2657	38.
11	1.0771	1.0467	.6091	0.0000	0.0000	0.0000	.4708	1.6646	3.4890	1.6646	5.1536	41.
12	1.6787	1.0962	.6378	0.0000	0.0000	0.0000	.4008	2.4689	3.6538	2.4689	6.1227	45.
	10.3663	13.0626	8.9688	0.0000	0.0000	0.0000	7.1281	15.8031	43.5421	15.8031	59.3452	38.

Total Electricity Consumption

Total Heating Fuel Consumption

CENTRAL PLANT ENERGY UTILIZATION SUMMARY

PLANT NUMBER= 1, CENTRAL PLANT

PLANT LOCATION = 68655 TORONTO - 1981 TDF1440 - TORONTO IAP,CAN SIMULATION PERIOD 1JAN1981 - 31DEC1981

MONTH	TOTAL HEAT ENERGY (GBTU)	TOTAL ELECTR ENERGY (GBTU)	COOLING ENERGY (GBTU)	RCVRED ENERGY (GBTU)	WASTED RCVRABL ENERGY (GBTU)	HEAT EN INPUT COOLING (GBTU)	ELEC EN INPUT COOLING (GBTU)	ENERGY INPUT HEATING (GBTU)	ENERGY INPUT ELECTRC (GBTU)	TOTAL FUEL INPUT (GBTU)	TOTAL ENERGY INPUT (GBTU)	AVERAGE PLANT EFFIC (PERCT)
1	1.6676	.5744	.0001	0.0000	0.0000	0.0000	.0007	2.4030	1.9145	2.4030	4.3175	52.
2	1.0558	.5381	.0009	0.0000	0.0000	0.0000	.0346	1.5938	1.7936	1.5938	3.3874	47.
3	1.0026	.6238	.0064	0.0000	0.0000	0.0000	.0612	1.5405	2.0792	1.5405	3.6196	45.
4	.5359	.7023	.0380	0.0000	0.0000	0.0000	.2217	.9040	2.3410	.9040	3.2450	38.
5	.3406	.7114	.1414	0.0000	0.0000	0.0000	.3155	.5994	2.3713	.5994	2.9706	35.
6	.1062	.7707	.4436	0.0000	0.0000	0.0000	.4221	.1998	2.5691	.1998	2.7689	32.
7	.0695	.8100	.6390	0.0000	0.0000	0.0000	.5024	.1331	2.7000	.1331	2.8332	31.
8	.0821	.7778	.5355	0.0000	0.0000	0.0000	.4647	.1552	2.5928	.1552	2.7479	31.
9	.2700	.7210	.2624	0.0000	0.0000	0.0000	.3292	.4807	2.4032	.4807	2.8839	34.
10	.6515	.7047	.0896	0.0000	0.0000	0.0000	.2327	1.0911	2.3490	1.0911	3.4401	39.
11	.8371	.5732	.0056	0.0000	0.0000	0.0000	.0772	1.3298	1.9106	1.3298	3.2404	44.
12	1.2221	.5909	0.0000	0.0000	0.0000	0.0000	0.0000	1.8256	1.9696	1.8256	3.7953	48.
	7.8410	8.0981	2.0827	0.0000	0.0000	0.0000	2.6620	12.2559	26.9938	12.2559	39.2497	40.

Total Electricity Consumption

Total Heating Fuel Consumption

CENTRAL PLANT ENERGY UTILIZATION SUMMARY

PLANT NUMBER= 1, CENTRAL PLANT

PLANT LOCATION = 53222 WINNIPEG - 1981 TDF1440 - WINNIPEG IAP, SIMULATION PERIOD 1JAN1981 - 31DEC1981

MONTH	TOTAL HEAT ENERGY (GBTU)	TOTAL ELECTR ENERGY (GBTU)	COOLING ENERGY (GBTU)	RCVRED ENERGY (GBTU)	WASTED RCVRABL ENERGY (GBTU)	HEAT EN INPUT COOLING (GBTU)	ELEC EN INPUT COOLING (GBTU)	ENERGY INPUT HEATING (GBTU)	ENERGY INPUT ELECTRC (GBTU)	TOTAL FUEL INPUT (GBTU)	TOTAL ENERGY INPUT (GBTU)	AVERAGE PLANT EFFIC (PERCT)
1	1.9624	.8483	0.0000	0.0000	0.0000	0.0000	0.0000	2.9552	2.8275	2.9552	5.7827	49.
2	1.4183	.7635	.0000	0.0000	0.0000	0.0000	.0019	2.1838	2.5450	2.1838	4.7288	46.
3	.7365	.8791	.0001	0.0000	0.0000	0.0000	.0731	1.2629	2.9304	1.2629	4.1933	39.
4	.7179	1.0709	.7368	0.0000	0.0000	0.0000	.6168	1.1591	3.5696	1.1591	4.7287	38.
5	.3213	1.0360	.7782	0.0000	0.0000	0.0000	.7976	.5414	3.4532	.5414	3.9946	34.
6	.2017	1.0152	.8796	0.0000	0.0000	0.0000	.7941	.3563	3.3840	.3563	3.7403	33.
7	.1078	1.0437	1.0795	0.0000	0.0000	0.0000	.8275	.2033	3.4790	.2033	3.6823	31.
8	.1089	1.0081	1.0280	0.0000	0.0000	0.0000	.8013	.2022	3.3604	.2022	3.5627	31.
9	.3902	1.0289	.8141	0.0000	0.0000	0.0000	.7833	.6361	3.4298	.6361	4.0658	35.
10	.4295	.9105	.0005	0.0000	0.0000	0.0000	.2914	.7461	3.0351	.7461	3.7811	35.
11	.7164	.8497	.0003	0.0000	0.0000	0.0000	.1510	1.2224	2.8322	1.2224	4.0545	39.
12	1.9104	.8652	0.0000	0.0000	0.0000	0.0000	0.0000	2.9039	2.8839	2.9039	5.7878	48.
	9.0211	11.3190	5.3171	0.0000	0.0000	0.0000	5.1380	14.3725	37.7301	14.3725	52.1026	38.

Total Electricity Consumption

Total Heating Fuel Consumption

CENTRAL PLANT ENERGY UTILIZATION SUMMARY

PLANT NUMBER= 1, CENTRAL PLANT

PLANT LOCATION = 53222 WINNIPEG - 1981 TDF1440 - WINNIPEG IAP, SIMULATION PERIOD 1JAN1981 - 31DEC1981

MONTH	TOTAL HEAT ENERGY (GBTU)	TOTAL ELECTR ENERGY (GBTU)	COOLING ENERGY (GBTU)	RCVRED ENERGY (GBTU)	WASTED RCVRABL ENERGY (GBTU)	HEAT EN INPUT COOLING (GBTU)	ELEC EN INPUT COOLING (GBTU)	ENERGY INPUT HEATING (GBTU)	ENERGY INPUT ELECTRC (GBTU)	TOTAL FUEL INPUT (GBTU)	TOTAL ENERGY INPUT (GBTU)	AVERAGE PLANT EFFIC (PERCT)
1	1.5093	.5998	0.0000	0.0000	0.0000	0.0000	0.0000	2.2863	1.9993	2.2863	4.2856	49.
2	1.1634	.5405	.0000	0.0000	0.0000	0.0000	.0013	1.8004	1.8016	1.8004	3.6020	47.
3	.7646	.6362	.0001	0.0000	0.0000	0.0000	.0512	1.2914	2.1205	1.2914	3.4119	41.
4	.5552	.6840	.0321	0.0000	0.0000	0.0000	.1467	.9575	2.2799	.9575	3.2374	38.
5	.2602	.7291	.1690	0.0000	0.0000	0.0000	.3457	.4642	2.4302	.4642	2.8944	34.
6	.1532	.7489	.2651	0.0000	0.0000	0.0000	.3455	.2829	2.4962	.2829	2.7791	32.
7	.0966	.8157	.6055	0.0000	0.0000	0.0000	.4949	.1879	2.7189	.1879	2.9068	31.
8	.0986	.8014	.6288	0.0000	0.0000	0.0000	.5097	.1899	2.6714	.1899	2.8613	31.
9	.2579	.7102	.1426	0.0000	0.0000	0.0000	.2891	.4516	2.3674	.4516	2.8190	34.
10	.4864	.6775	.0005	0.0000	0.0000	0.0000	.2014	.8391	2.2585	.8391	3.0976	38.
11	.6986	.6039	.0003	0.0000	0.0000	0.0000	.1057	1.1821	2.0129	1.1821	3.1950	41.
12	1.4605	.6151	0.0000	0.0000	0.0000	0.0000	0.0000	2.2315	2.0505	2.2315	4.2820	48.
	7.5045	8.1622	1.8439	0.0000	0.0000	0.0000	2.4913	12.1647	27.2073	12.1647	39.3720	39.

Total Electricity Consumption

Total Heating Fuel Consumption